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The National Wireless Electronic Systems Testbed: Initial Development

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Abstract

The U.S. National Institute of Standards and Technology and the U.S. National Telecommunications and Information Administration are developing the National Wireless Electronic Systems Testbed (N-WEST), an experimental facility for characterizing the performance of wireless systems and the dependence of their performance on components, subsystems, modulation, propagation, interference, and other factors. N-WEST will distribute its data widely among its participants with the intention that they will come to compatible conclusions on technical grounds and thereby to consensus regarding appropriate operational standards and component specifications. N-WEST will focus much of its early effort on broadband wireless services in the millimeter-waves bands, particularly on the 28-31 GHz Local Multipoint Distribution Service auctioned to the private sector in early 1998.

INTRODUCTION

The National Wireless Electronic Systems Testbed (N-WEST) is an experiment in how federal agencies within the U.S. Department of Commerce can coordinate with commercial enterprise to accelerate the development and standardization of superior wireless technology. This would be perhaps the only such U.S. effort, since radio spectrum sold at auction in the U.S. is virtually unregulated and the government provides very little in the way of infrastructure or coordination. The result can be a fractured marketplace with numerous standards, none of which is strong enough to quickly drive down costs. N-WEST is beginning an effort to accelerate the standardization process, first focussing on broadband wireless services in the millimeter-waves bands, particularly on the 28-31 GHz Local Multipoint Distribution Service (LMDS) auctioned to the private sector in February and March of 1998.

The N-WEST vision is of many major corporations in the LMDS business voluntarily participating to quickly build the technical foundations of a strong and vital LMDS industry. N-WEST will seek as partners the LMDS license holders, systems manufacturers, and component suppliers. The technical thrust of the testbed is to evaluate the performance of prototype systems and the dependence of that performance on modulation, coding, propagation, interference, components, and other critical factors. By exposing key industry players to the same sets of data, N-WEST intends to provide the industry with a sound technical basis for consensus operational standards. At the same time, correlating system performance to component-level characterization carried out in federal laboratories will provide the data needed to establish realistic component specifications that ensure functionality without building in excess costs due to overspecification.

N-WEST will be coordinated by the National Institute of Standards and Technology (NIST) with the participation of the Institute for Telecommunication Sciences (ITS) of the National Telecommunications and Information Administration (NTIA).

THE DEREGULATED SPECTRUM

The need for voluntary industry consensus on standards arises from deregulation. The United States Government, represented by the Federal Communications Commission (FCC), began in 1994 to move spectrum to private hands in a series of auctions. Spectrum bought at auction is nearly completely deregulated, so that license holders are free to use it for virtually any service. In this competitive environment,

superior technologies should eventually win out. On the other hand, it may take many years for this superiority to assert itself in the marketplace. In the meantime, a multitude of standards may coexist. This entails convenience and expense on the part of the service providers, system integrators, component manufacturers, and customers. It also weakens U.S. industry with respect to international markets. No federal agency has taken on the task of encouraging the commercialization of the privately held spectrum to the advantage of U.S. industry or consumers.

In a 1996 address [1], FCC Chairman Reed Hundt contrasted the advantages of the U.S.'s market approach regarding personal communications systems (PCS) technology to Europe's government-mandated standards. He strongly argued that the U.S. approach would bring the latest technology to market faster and more efficiently. While the U.S. approach did indeed yield a strong showing for spread spectrum technology, it also left a fractured marketplace with several standards and an inconvenient patchwork of incompatible systems. This results in added cost for equipment suppliers and system operators. Many wireless engineers now prefer government-mandated standards to unregulated licenses [2].

GOALS OF N-WEST

The National Wireless Electronic System Testbed (N-WEST) acknowledges the freedom of the marketplace but seeks to coordinate the industry by forging industry consensus standards in wireless communications. Such consensus will be driven by technical considerations illuminated by measurements.

N-WEST will begin with bands in the 28-31 GHz range that the FCC has recently auctioned for LMDS (see Appendix). N-WEST will provide a testbed for the study of LMDS system performance and its dependence on critical parameters. The results should provide industry with the technical information needed to develop system design choices that become consensus standards. Such standards do not currently exist, even though some early efforts have been made by the Geneva-based Digital Audio-Visual Council [3].

Although the LMDS auction is complete, the launch of LMDS on a wide scale is not imminent. The problem is that many systems remain at the prototype level. The system integrators have not yet answered many of the key technical questions that influence basic system design choices. When they have answered such questions, the solutions have generally been proprietary. In order to make well-founded technical decisions, system designers need good performance data or, failing that, the combination of reliable system simulation tools and reliable component-level measurements. At present, none of these tools is widely available.

Critical measurement technology will be developed at NIST and NTIA and by industrial partners as part of N-WEST. In addition, the testbed will tie closely to NIST and NTIA work in fundamental measurements for wireless communications. The testbed will operate in NIST and NTIA/ITS laboratory facilities in Boulder, Colorado, with collaborative participants in NIST's Gaithersburg, Maryland headquarters facility. Industrial partnerships will be sought with all those with an interest in standards; this includes license holders, system integrators, and component manufacturers. As LMDS matures, N-WEST will begin to tackle new frontiers of the radio spectrum.

TESTBED APPROACH

N-WEST will be a testbed for LMDS systems, serving as a means of performance assessment and hopefully leading to operational standards. We plan to borrow realistic communications equipment from LMDS system developers. We will characterize this equipment using existing technology or new technology we develop. By careful study of system performance, we hope to offer industry the data with which to make intelligent system design choices that can be incorporated into industry consensus standards.

N-WEST intends to develop facilities equipped with realistic prototype LMDS systems. We aim to develop characterization tools to study the performance of these systems and then characterize them under a number of different conditions. We intend to have access to both laboratory measurements, in which transceivers are connected by cable, and free space propagation measurements, in which transceivers interface by antenna and one or more transceivers can be moved to sites of varying topography. Details will be developed and refined in conjunction with industry.

Another important challenge of N-WEST is to help define acceptable components. At present, system performance cannot be evaluated based

on component-level measurements, primarily because of significant nonlinear effects in the components. Simulator limitations are part of the problem. Moreover, existing component-level characterization schemes may not even be measuring the right parameters to successfully predict system performance. An important goal of the testbed is to address this problem by measuring system behavior as a function of the component building blocks. This requires first developing basic component characterization methods and then correlating measured system performance to measured component characteristics. Armed with the resulting data, industry will be equipped to make realistic component specifications that guarantee system performance without burdening suppliers with unnecessary expense. This will strengthen the tie between system integrators and their component suppliers.

The key issues for the NIST Measurement and Standards Laboratories are the fundamental measurements and standards required to evaluate wireless systems. Many of these fundamental measurements will be at the system level, for aspects such as the characterization of digital modulation and modulation schemes. Many others will be at the component level, focusing on defining the component characterization parameters that are needed to accurately simulate systems and then identifying schemes to accurately measure these quantities.

The Institute for Telecommunication Sciences of NTIA intends to develop a state-of-the art measurement system capable of making broadband measurements to characterize the radio channel for realistic LMDS environments. It will then conduct measurements of the broadband radio channel to determine environmental effects. It will apply these results to the development of radio channel modeling tools. In parallel to the propagation work, NTIA/ITS will develop system level modeling software and use it to evaluate system performance.

STANDARDIZATION

N-WEST is attempting to coordinate a standardization activity in parallel to its testbed development. N-WEST can then serve as a measurement resource for the standards committee. The appropriate standards body to support such an effort will be industry driven and will support rapid progress.

ORGANIZATIONAL EFFORTS

With the aid of interested industry representatives, N-WEST will develop a draft plan of action and seek to establish consensus on this plan during a workshop in August, 1998 in conjunction with the 1998 IEEE Radio and Wireless Conference in Colorado Springs, Colorado.

APPENDIX: WHAT IS LMDS?

From February 18 until March 25, 1998, the FCC carried out an auction of spectrum in the 28-31 GHz range for a service known as LMDS (for "Local Multipoint Distribution Service"). In each geographical area, the FCC auctioned an "A block" (with bandwidth of 1150 MHz) and a "B block" (with bandwidth of 150 MHz). Net revenue was $578,663,029. FCC Chairman William E. Kennard said, "The marketplace now has 104 new LMDS players. LMDS operators have the potential of being the next serious players offering real competition in the local loop. This can only lead to great things for consumers" [4].

Although license holders will be free to use the spectrum as they wish, we anticipate that they will develop two-way systems based on fixed antenna sites. In addition to multichannel consumer video, "it has become clear that LMDS licensees will also be able to offer local exchange telephone service, internet access, and other broadband services. It is expected that this assortment of services will benefit not only residential and business consumers but can also assist in fulfilling the telecommunications and information technology needs of schools, libraries, health care providers, and rural communities" [5]. Service providers are expected to target either the consumer market (providing video distribution, high speed Internet, and telephone service) or the commercial market (providing very high speed data). Prototype systems involve "hub" transceivers on towers spaced a few kilometers apart. Each hub is at the center of a cell serving perhaps several thousand homes with small rooftop antennas. The hubs will likely be connected with optical fiber, possibly using ATM (asynchronous transfer mode).

The LMDS bandwidth is by far the largest ever auctioned. For instance, using just the 850 MHz "downstream" band, one system developer expects to be able to offer 76 digital broadcast video channels to all users in a given cell while setting aside 1555 Mbit/s (equivalent to 1080 T-

1 lines) for interactive data channels [6]. This could be allocated into many channels (for example, 370 residential lines at 4 Mbit/s each) or only a few channels (for commercial users with large scale data requirements). Similar services can be provided to the users in adjacent cells; the frequencies can be "reused" due to the short propagation path of 28 GHz radio waves and, in some schemes, by controlling the wave polarization.

Major investments in infrastructure and customer premises equipment will be required before LMDS can fulfill its promise. Infrastructure costs have been estimated at $125-$225 per covered household and total cost per subscriber at $1000 or more [7]. A telecommunications marketing consultant has estimated customer premises equipment cost as $650 per home [8]. It is reasonable to estimate the value of LMDS in the United States as at least several billion dollars. A recent study predicted that the LMDS market in the United States could exceed $1 billion in service revenues in 2012, or much sooner if operators move into the consumer video market [9].

LMDS is not confined to the United States. For instance, on October 29, 1996, Canada awarded nationwide licenses for 1 GHz bandwidth in the 28 GHz range for what they call "LMCS." Canadian Industry Minister John Manley said, "LMCS applicants propose to invest over $1 billion and create up to 8,000 new jobs over the next five years in the wireless industry. We want competition in the cable and local telephony markets as soon as possible" [10]. Western Europe (particularly the U.K.) has a well-supported broadband "MVDS" service in development near 40 GHz. It is currently primarily analog and one-way [11]. Canada, Argentina, the U.K., France, Korea, the Philippines, Romania, and Venezuela have allocated LMDS spectrum [12].

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